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U. S. DEPARTMENT OF AGRICULTURE.

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Experiment Station Work—III.

FLAX CULTURE.

CRIMSON CLOVER.

FORCING LETTUCE.

HEATING GREENHOUSES.

CORN SMUT.

MILLET DISEASE OF HORSES.

TUBERCULOSIS.

PASTEURIZED CREAM.

KITCHEN AND TABLE WASTES.

USE OF FERTILIZERS.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., December 15, 1897.

SIR: The third number of Experiment Station Work, prepared under my direction, is transmitted herewith with the recommendation that it be published as a Farmers' Bulletin.

Respectfully,

A. C. TRUE,
Director.

Hon. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

	Page.
Flax culture	5
Crimson clover	8
Forcing lettuce in pots	10
Heating greenhouses	12
Is corn smut injurious to cattle?	16
Corn smut	18
Millet disease of horses	20
Tuberculosis	21
Restoring the consistency of pasteurized cream	23
Kitchen and table wastes	25
Suggestions regarding the systematic use of fertilizers	26
Explanation of terms	30
Terms used in discussing fertilizers	30
Terms used in discussing foods and feeding stuffs	30
Miscellaneous terms	31

ILLUSTRATIONS.

FIG. 1. Effect of smut on ear of corn	19
2. Microscopical appearance of corn smut	20

EXPERIMENT STATION WORK—III.¹

FLAX CULTURE.

Attempts to grow flax in the United States have been most successful on the fertile virgin soils of the Northwest. In fact, at the present time practically the entire flax crop of the United States is grown west of the Mississippi River. The fact that flax has been successfully grown only on such fertile soils has led to the quite general belief that this crop makes a heavy draft on the fertility of the soil.

The Minnesota Station has recently made some investigations which throw considerable light on this point. Flax plants were analyzed at different stages of growth, and studies were also made of different soils on which flax had been grown with varying degrees of success. From the analyses of the flax crop, as well as of other crops ordinarily grown in the same region, the table (p. 6), showing the approximate amounts of plant food removed by average yields of these crops, has been prepared. This table shows that many of the crops ordinarily grown remove more plant food from the soil than the average flax crop. This is strikingly true in the case of corn. The oat crop removes about the same amount of nitrogen and phosphoric acid but nearly as much again of potash as the flax crop. The necessity for a fertile soil in successful flax growing is not due, therefore, to the fact that this crop requires larger total amounts of fertilizing constituents than other common farm crops, but to the fact that although it is a somewhat

¹This is the third number of a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint our farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director Office of Experiment Stations.

dainty feeder with a small root system, it must secure the necessary plant food for its perfect growth in a short growing period of from sixty to one hundred days. The plant food, therefore, must not simply be abundant, but it must be in a readily available form.

Plant food per acre removed by various farm crops.

Crops.	Weight per acre.	Nitrogen.	Phosphoric acid.	Potash.	Lime.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
Wheat, 20 bushels.....	1,200	25	12.5	7	1
Straw.....	2,000	10	7.5	28	7
Total.....		35	20	35	8
Barley, 40 bushels.....	1,920	28	15	8	1
Straw.....	3,000	12	5	30	8
Total.....		40	20	38	9
Oats, 50 bushels.....	1,000	35	12	10	1.5
Straw.....	3,000	15	0	35	9.5
Total.....		50	18	45	11
Corn, 65 bushels.....	2,200	40	18	15	1
Stalks.....	3,000	35	2	45	11
Total.....		75	20	60	12
Peas, 30 bushels.....	1,800		18	22	4
Straw.....	3,500		7	38	71
Total.....			25	60	75
Mangel-wurzels, 10 tons.....	20,000	75	35	150	30
Meadow hay, 1 ton.....	2,000	30	20	45	12
Red clover hay, 2 tons.....	4,000		28	66	75
Potatoes, 150 bushels.....	9,000	40	20	75	25
Flaxseed, 15 bushels.....	900	39	15	8	3
Straw.....	1,800	15	3	19	13
Total.....		54	18	27	10

The table shows further that the heaviest draft in flax culture is made upon the nitrogen of the soil, and this fact, taken in connection with the further fact that nitrogen is more abundant in virgin soils than in those which have been cultivated, explains the greater success of flax culture on new land. It furnishes, also, a strong reason why clover should be included in the rotation with flax.

The same station has also undertaken to determine the reason why flax can not be grown continuously on the same soil. Experiments on this subject show that "the flax straw and roots in their decomposition produce products which will destroy the following flax crops. When five or seven years intervene between two flax crops, then the old straw and crop residue is thoroughly decomposed and will not injure a new flax crop." Unless new land is available, therefore, it becomes necessary to grow flax in rotation with other crops.

The Oregon Station, which has given considerable attention to flax growing for fiber, recommends the following rotation: First, wheat; second, oats and barley; third, clover and grasses; fourth, clover and grasses; fifth, corn and potatoes; sixth, flax. "The object of the culti-

vated crops in the rotation is to clean the ground of weeds, and by placing such crops just preceding flax this will be better obtained than when they occur earlier in the course." As stated above, clover is valuable for restoring the nitrogen. "Green manuring and the plowing in of clover stubble will be the most economical method of keeping up the fertility of flax land. If barnyard manure is used at all it should be well rotted." The rotation should always be arranged with a view to freeing the soil from weeds.

The soil selected for flax should be an open loam, well supplied with humus (decayed animal and vegetable matter), and should contain large amounts of available nitrogen. "Fall plowing rather than late spring plowing is better for flax, because the nitrogen is brought into better condition for the use of the crop. Late spring plowing brings the raw nitrogen to the surface and buries the available nitrogen, which is disastrous to the germinating and starting of the flax crop in the spring."

Since, as already explained, flax has a comparatively small root system and must take up the necessary plant food in a comparatively short growing season, a deep and thorough preparation of the seed bed is of the highest importance. It is recommended to plow as deep as possible in the fall or winter and to cross-plow again in the spring about 6 inches deep. Subsoiling improves the drainage and deepens the soil for the flax roots. If the plowing is delayed until spring, it is suggested that it be done as early as possible. Fall or early spring plowing allows the weeds to start growth before the seed is sown, and in the final preparation of the seed bed the weeds are destroyed. Before seeding, the surface soil is usually pulverized by means of a clod masher and a harrow.

If flax is grown simply for seed, a carefully selected home-grown seed may be used, but for the production of fiber imported seed is necessary. Even in Ireland, where the industry is very old, seed is still imported from Russia or from Holland. Probably the best varieties of imported seed are those produced by plants grown on Belgian soil from seed imported from Riga, Russia; Riga seed, imported direct from Russia; and Dutch seed. In experiments at the Oregon Station, the seed imported direct from Riga, Russia, gave the best results.

"When the ground is warm enough to germinate corn quickly, flax seed will germinate and the young plants will make a rapid growth. Care must be taken not to sow too late, and yet late enough to enable the farmer to thoroughly prepare the ground." The amount of seed to be sown per acre is given as 3 pecks when sown for seed alone, and as 2 or 2½ bushels when grown for fiber. When grown for seed alone, the branching of the plant is thought desirable, and hence thin seeding is necessary and may be done with the drill; but when the plant is grown for its fiber, thick seeding and broadcasting is practiced to prevent branching, and to produce a long, straight straw—conditions which favor the production of fiber of a good quality. The

seed is covered by a light harrowing, and in order that this may be done satisfactorily the soil must be in a thoroughly pulverized condition. Heavy rains are likely to form a hard crust on rolled ground; hence it is advised that the rolling be done at times when rains are least frequent. The harrow should follow the roller to lessen the tendency of forming a crust on the surface in case of heavy rains, and also to conserve the soil moisture by the dust mulch made by the harrow. It will thus be seen that with the possible exception of more thorough preparation of seed bed, the culture of flax up to this point is much the same as that required by wheat.

With regard to harvesting, it is recommended that "flax should be pulled when the lower leaves turn yellow and the lower part of the stem begins to turn." Much valuable flax is ruined by letting it get too ripe. The yield of seed will not be so large, but the increase in value of the fiber product will more than make up for the loss." The stage of maturity which the plant is allowed to reach will depend, therefore, upon the purpose for which it is grown. The largest amount of seed will probably be secured by allowing the plants to become thoroughly mature. If grown for fiber it will probably be best to harvest at a somewhat earlier stage. After pulling, the flax is put in stooks to dry, the seed ends being tied together, the bottom ends opened out. "After drying in the stook, handfuls of straw are tied into small bundles or 'beets' and piled, something as cord-wood is piled in this country, two poles being first laid upon the ground to prevent injury to the bottom layer by dampness, and two poles driven at each end of the pile to keep the hedges in form." If flax is grown simply for seed, it may be put through an ordinary thrashing machine. If the fiber is also to be saved, the seed must either be removed by hand or by one of the special flax thrashers which are found on the market.

Retting, the process of separating the woody portion of the straw from the fiber, is performed by exposing the straw to the dew or by placing it in ponds or rivers. This produces decomposition or fermentation, by means of which the gum which binds the fiber to the woody portion of the stalk is dissolved, allowing the fiber to separate freely from the worthless portion of the stem. As a rule, the preparation of the straw for fiber will be carried on by the purchaser of the straw, therefore the details of this process are not of special importance to the farmer; his principal concern will be to produce a raw material which may be made into a high-grade manufactured product, and will thus command a remunerative price.

CRIMSON CLOVER.¹

In view of the increasing importance of crimson clover as a forage plant and green manure, experiments in its culture are of special interest to farmers. Recent experiments by the New Jersey and Michigan

¹ Also known as scarlet clover, German clover, etc.

stations throw some light on the best time and manner of seeding this crop under different conditions of soil and climate.

In one of the New Jersey experiments the clover was seeded on rather heavy clay loam soil August 4, 13, 29, and October 1. The yields of clover ranked in the order of seeding, the best results being obtained from the earlier seedings. The difference between the crops of the first and second seedings was very small. The seeding of October 1 proved a failure.

The second experiment was made on a soil ranging from a coarse sand to a sandy loam. The crop from seed sown July 11 was destroyed by hot weather soon after coming up. Seed was sown July 21 among tomatoes, but the plants were again destroyed by the hot weather. From seed sown the same day among citron vines, which gave better protection than the tomato vines, a thin stand was obtained and the plants made a good growth the following spring. Seed sown August 4 on a plat on which a crop of peas had been turned under gave satisfactory results except that the plants lodged. August 18 seed was sown among late tomatoes. A good stand was obtained and the crop made a vigorous growth. Seed was sown September 14 and the plants came up in three days. A good stand was obtained and the growth during the fall was promising. The plants, however, were small when winter set in, and, being unprotected, many were killed, while the rest were stunted. Seed was sown September 20 in a citron patch, being put in with a cut-away harrow. The plants were protected by crab grass and the remaining citron vines and stood the winter well, but were small as compared with those of the earlier seeding. Seed was sown about the same time and in the same manner on an old sand field, but being without protection many of the plants were destroyed during the winter. A stand of clover was obtained, however, from seed sown in an orchard September 29 and put in with a cut-away harrow. Of the seeding made with rye October 4 and 23, but few plants survived the winter, and the majority of those had but a single branch.

In the third experiment on sandy-loam soil the seed sown with rape June 8 gave a rather uneven stand, but the crop made a good growth during the fall.

At the Michigan Station a plat of half an acre of crimson clover was sown with oats in the spring. After the oats were cut, the clover made a rapid growth, yielding 5,134 pounds when cut for green feed October 23 and November 12. Another similar plat sown without grain grew rapidly from the start, and when cut, June 24, yielded 1,870 pounds green feed, or 418 pounds of hay. "It produced a second crop, on which sheep were pastured for about six weeks during August and September. After the sheep were removed, it made another small growth."

At the same station, in 1896, a one-tenth-acre plat each of crimson and red clover was sown the last day of every month, beginning in March. The yield of crimson clover on the whole was apparently

somewhat greater than that of the red clover. "The March crop of crimson clover matured a crop of seed early in August, but the plants, instead of dying thereafter, as in previous years, continued to put forth blossoms until checked by the hard frosts of autumn. Late in October nearly all the plants on this plat died. The April plat did not seed so abundantly, but the plats which seeded freely died at the same time as those in the other plat. The plats which produced little or no seed remained green and thrifty. The plats sown the last of May produced only now and then a blossom head and entered the winter with a thick mass of verdure about 8 inches deep. The later-sown plats were of successively smaller growth as the season advanced. The plats sown after the 1st of August made so little growth that, judging from previous experiments, they are not likely to survive the winter."

In general it appears that in New Jersey crimson clover seeded from August 4 to 18 gave the best results, but that in Michigan these dates were too late to permit the plants to make sufficient growth before winter. It is evident that wherever crimson clover is grown it should be sown at such a time as will enable it to make a good stand and sufficient growth before it is checked by the frosts. Spring seeding in the climate of Michigan seems to give very satisfactory results. A good crop is secured the same year and the clover is apparently left in good condition to withstand the ensuing winter. The date of seeding alone, however, does not insure success. The latter depends also upon moisture and protection. Moisture is necessary for the sprouting of the seed and the subsequent growth of the plant. A light shower of rain is often sufficient to start the seed growing, but, if drought follows, the young plants frequently die for want of moisture, as occurred in the New Jersey experiments on sandy soil. It should be noted, also, that in the experiments cited better results were obtained where plants were protected by growing crops or by the rubbish left after harvesting, particularly in case of the drier sandy soils seeded in summer and early fall.

FORCING LETTUCE IN POTS.

The ability to keep lettuce crisp and attractive for a considerable time after marketing is important not only to the salesman but to the grower and consumer as well. As usually marketed, in a few days it either wilts from lack of moisture or its leaves begin to spoil from being kept too wet. In either case it is unattractive and therefore much reduced in value. Attempts to overcome this difficulty with forced lettuce by growing it in pots have been reported by two experiment stations.

At the New York State Station lettuce seed was sown in shallow flats in the ordinary way and the seedlings transplanted into pots when about 2 inches high. The pots were then plunged 10 inches apart in soil on benches so that the pots were covered with about one-half inch

of soil. The potting soil was composed of equal parts of loam, manure, and sand. The benches contained 3 inches of well-rotted manure and above it 3 inches of potting soil. The plants made a more compact growth and headed quicker when grown in pots than when grown in beds. The report suggests that, in marketing, the plants be removed from the pots without disturbing the roots and that the balls of roots and soil be wrapped in oiled paper; or, if for local consumers, it suggests that the lettuce be marketed in the pots and the pots returned when the plants are removed. In either case the roots could be kept moist and wilting prevented.

At the Tennessee Station lettuce seed was sown in shallow flats of fine, rich, sandy soil. The young plants were set in similar soil in pots of various sizes, and the pots were plunged close together in a bed of sand. In about a month they were transplanted to permanent beds containing 8 inches of soil, one part sand, one part well-rotted manure, and two parts loam, to which was added a liberal amount of muriate of potash and dissolved rock phosphate. The pots were set about a foot apart each way and covered with one-half inch of soil. At intervals during growth the plants received applications of a solution of nitrate of soda. A month in this bed was sufficient to mature the crop.

Pot culture economized time by allowing the young plants to be kept in a bed of sand while older ones occupied the permanent beds, and economized space by allowing the plants to be set close together in the sand bed.

The use of pots was found to decrease the yield about 15 per cent; but this is not considered a serious disadvantage by the author unless the crop is sold by weight. There was little difference in the yield of lettuce in 2-inch and 3-inch pots. Pots smaller than 2 inches were found impracticable. Those larger than 3 inches were too expensive and the balls too large for convenient marketing. The report recommends 2-inch pots both for economy and convenience.

In marketing, some of the plants were slipped out of the pots and wrapped in oiled paper and others were left in the pots. The first method was not entirely satisfactory; the plants wilted unless careful attention was given to watering them. When they were left in the pots, however, one watering a day was sufficient to keep the leaves crisp for a week or more. Marketed in pots, about a dozen together in a flat, lettuce presented a very attractive appearance, which increased its value fully one-third on the Knoxville market. The disadvantages of pot culture were the expense of the pots and a slight increase of expense in marketing.

The Indiana Station has recently reported results of two tests to determine the effect of the use of pots on the growth of lettuce. In the first test Grand Rapids and White Seeded Tennisball lettuce were grown. Two weeks after the seed was sown the young plants that were to be grown in pots were transplanted into 2½-inch pots and those

that were to be grown in the open bed were transplanted into flats. Between two and three weeks later the plants were set $7\frac{1}{2}$ by 8 inches apart in a bed, where they remained about ten weeks. At the time of transplanting into the bed the White Seeded Tennisball plants grown in flats were about 26 per cent higher than those grown in pots and the Grand Rapids grown in flats about 13 per cent higher than those grown in pots. During the first part of their growth in the bed the plants were subwatered and during the last part surface watered.

At the time of harvesting the crop the average weight of the White Seeded Tennisball plants grown without pots was about 24 per cent greater than that of the ones grown in pots. The Grand Rapids plants grown without pots averaged about 44 per cent heavier than those grown in pots.

In the second test Grand Rapids lettuce was used alone. Instead of transplanting part of the young seedlings into flats, as was done in the previous test, all of them were potted. When placed in the permanent bed part of the plants were removed from the pots and the others were plunged in the soil with the pots as in the first crop. The two lots of plants were of equal size when set in the bed. They were watered from the surface entirely. The plants remained in the bed about seven weeks. When harvested the plants grown in the open bed without pots averaged about 35 per cent heavier than those grown in pots.

The author of the Indiana bulletin believes that pot culture of lettuce has no advantage over other methods; for if the plants are lifted with a trowel, about as much soil will remain on the roots as if grown in pots. In regard to this point, however, no experiments have been reported.

From the experiments noted, it seems clear that as regards weight of crop pot culture is at a considerable disadvantage. It seems equally clear that marketing plants in pots has a marked advantage over the ordinary methods. Whether removing plants from the bed with a trowel, so as to keep soil about their roots in marketing, would prove as satisfactory as marketing them in pots has not been determined. The method to be chosen will depend largely upon the market for which the crop is grown.

HEATING GREENHOUSES.

A number of problems connected with the heating of greenhouses have been studied by various stations. Among these the question of the relative merits of steam and hot-water heating has received most attention. While the results of experiments by different stations are apparently contradictory in some respects, certain points have, nevertheless, been brought out with considerable definiteness. The experiments have not determined which is the best method for all purposes under all conditions, but they have pointed out certain advantages and disadvantages of each system under certain conditions.

The results reported indicate, that for small houses with comparatively straight runs and good fall, hot water has the advantage in economy and efficiency. At the Massachusetts Hatch Station this result was obtained from a test continued through two seasons with two houses of like construction and equal size, one heated with hot water and the other with steam. The boilers used were of the same size and pattern, one being fitted for steam and the other for hot water. The hot water kept the temperature of the house from 1° to 2° F. higher than the steam and with the consumption of 20 to 30 per cent less coal. At the Michigan Station, where similar results were obtained, two small houses, alike in size and construction, were used, one being heated with steam and the other with hot water. In this case the hot-water pipes had a radiating surface of 1 square foot to 4 square feet of glass, while the steam pipes had 1 to $5\frac{1}{2}$, the greater radiating surface of the hot-water pipes being intended to balance the higher temperature of the steam pipes. The heaters were as near alike as possible. The hot-water system was arranged with an expansion tank 18 feet above the lowest part of the system, so that the water was under some pressure. During the greater part of the time the steam had no pressure. During the first trial the house heated by hot water had an average temperature of 1.85° F. higher than the steam-heated house, while the coal consumed in the hot-water system was about 17 per cent less than in steam heating. During the next test the same amount of coal was consumed by both heaters with a resulting temperature of 7° F. higher in the house heated with hot water than in the steam-heated one. It is probable, as will be seen from results of experiments made at another station, that the pressure of the hot water gave it some advantage over the steam, though it seems improbable that the difference in pressure was responsible for all the difference observed in the results.

In regard to the relative economy of fuel in steam and hot-water heating for a large range of houses, little work has been done. At New York Cornell Station, where a house was heated alternately with steam and hot water, the same boiler and pipes being used in both cases, the coal consumption was in the first test practically the same in both cases and the difference between minimum outdoor and indoor night temperatures was slightly in favor of hot-water heating. The house used was small, but difficult to heat on account of little fall and many angles in the piping system. Neither steam nor hot water was under much pressure. In the test made the next season with the same house and heating system, steam proved to be more efficient than hot water, the average quantity of coal used daily being the same in both cases. The question of fuel economy under the conditions noted has therefore been left unsettled. Several important points were brought out, however, in favor of steam heating by the work at Cornell.

The first season three series of houses, varying in character, requiring many elbows and affording little fall in the pipes, were used. Two

series were heated with steam; the other series was heated with hot water. The boilers, though of different pattern, had equal heating surfaces. In this test it was found that the steam pipes had at all times throughout their entire course a higher temperature than the hot-water pipes. The fluctuation of temperature in the flow pipes was greater in the case of hot water than in the case of steam. Steam heat was distributed through a greater length of pipe than water heat, which is an advantage in long runs. Tests the second year were made in a small house, the piping of which, as in the house used before, contained numerous angles and had but little fall. The heating system was used in alternate periods for steam and hot water. The heater was constructed for hot water. A low-expansion tank affording some, though little, pressure was used with hot water, being shut off, of course, when steam was used. The steam, as a rule, was under no pressure. Steam showed a great advantage in the rapidity with which the system could be heated up. Water was found to warm sufficiently to begin circulation almost at once after the fire was started, but about two hours were necessary to warm it enough to give much heat to the house. With steam the pipes showed no rise of temperature thirty minutes after starting the fire, but in forty minutes they were heated to their usual temperature. After adding considerable pipe to the system and raising the expansion tank so as to give the water a pressure of about $3\frac{1}{2}$ pounds, it was found that hot water, in passing through 84 feet of pipe, was reduced in temperature nearly 55° F., while the steam was reduced only 7° F., thus verifying the results previously obtained in favor of the better circulation of steam in long runs.

All this shows that in choosing the method of heating it is necessary to consider the conditions under which the heating is to be done. The economy of material and construction as well as of operation deserves notice. Since steam can usually be kept at a higher temperature than hot water, less radiating surface need be furnished in the former case than in the latter. This is usually accomplished by having fewer heating pipes in the case of steam than in the case of hot water. The first cost of a hot-water system, therefore, is usually somewhat greater than that of a steam system. This difference may, however, be more than overbalanced by the less cost of operation with hot water, provided the house to be heated is small and the pipes are arranged to afford easy circulation.

The relative efficiency of steam and hot water depends quite largely upon the pressure to which they are subjected, as was shown in the work at Cornell Station. In case of steam, pressure was found to increase the temperature of the pipes somewhat throughout their entire course. The increase was much more noticeable in the returns than in the flow pipes. Pressure increased the rapidity of circulation and hence gave a more uniform temperature throughout the system. The effect of pressure on hot-water circulation was shown to be similar to that on steam. For making this study, the heating system of the small

house noted several times above was fitted with two expansion tanks, one 10 feet above the top of the heater and the other 20 feet above. By changing from one to the other considerable difference of pressure could be had. In passing from the boiler to the opposite end of the house, hot water with the low expansion tank lost from 29° to 30° F., and with the high tank from 18° to 25° F. Low pressure enabled the steam to overcome obstacles in the circulation almost entirely. A straight flow pipe 21 feet long had a section about 2 feet long cut out and a set-off, or crook, put in its place, thus introducing four right angles into the course of the circulation. The temperature of the steam and hot water inside of the pipe was taken at the boiler and at the opposite end of the house, both with and without the set-off. The difference in the temperature of hot water under slight pressure at the two ends of the pipe without the set-off was 14° F., with the set-off 47° F.; of steam under no pressure without set-off 21° F., with set-off 70° F.; and of steam under one or more pounds pressure without set-off 1° F., with set-off 1° F. This means that the set-off checked the circulation so that water under slight pressure lost 33° F. of temperature in passing it, and that steam under no pressure lost 49° F. The circulation of steam under one or more pounds pressure was apparently not checked at all by the set-off.

The question of overbench *vs.* underbench heating of greenhouses has received some attention at the Massachusetts Hatch Station. In one of two houses alike in construction and both heated with hot water, the pipes were arranged above the benches, in the other below them. The temperature of the hot water furnished the house with overbench pipe averaged 4.8° F. higher than that furnished the one with underbench pipe, but the resulting house temperature averaged practically the same in both cases. This seems to indicate that more heat was lost from the overbench pipes than from the underbench ones. About 5 per cent less coal was required to heat the house with underbench pipes than to heat the other. The heat was more uniformly distributed above and below the benches in the former house than in the latter. Lettuce and carnations did better, cuttings of a number of plants rooted better, and several kinds of seeds germinated better in the house with the underbench pipes. Plants with flower buds already formed when put in the houses were forced into flower sooner in the house with overbench pipes than in the other. At the Ohio Station mushrooms did better with overhead pipe. With lettuce, radishes, cucumbers, tomatoes, and pieplant the results were negative except for a slight tendency of the plants to grow spindling in the house with overbench pipe. Here again the method to be chosen depends more or less on the conditions under which it is to be operated and the purposes for which it is to be used. In many cases a combination of the two methods is probably best.

The question of large cast-iron pipes *vs.* small wrought-iron ones for hot water in a small house, was studied at the Rhode Island Station.

The piping consisted of equal lengths of 4-inch cast-iron pipe and of 1½-inch wrought-iron pipe. The large pipes had therefore two and two-thirds times as much radiating surface as the small ones. The two kinds of pipe were used on alternate days throughout the test, the change from one to the other being made at noon. At each change the water was drawn from the heater and pipes, they were refilled with cold water, and the fire was started anew. When the large pipes were used, the temperature in the house averaged higher, but more coal was burned than when the small pipes were used. The quantity of coal consumed for each degree of difference between the average outdoor and indoor temperatures was practically the same in both cases. The results show, then, that as regards economy of fuel there was no perceptible difference between the two systems. Had the radiating surface in the two cases been equal the results might have been different.

The large pipes were found to cool off very much more slowly than the small ones. In three hours after the fire was drawn the large pipes had cooled down on an average about 70° F., while the small ones had cooled about 100° F. Probably on account of this difference in rapidity of cooling, the large pipes maintained the temperature of the house better toward morning, when no care was given to the heating. When the large pipes were used the average temperature of the house at 6 p. m. was 1.1° F. higher, at 9 p. m. 1.5° F. higher, at 12 p. m. 2° F. higher, and at 6 a. m. 3.5° F. higher than when the small pipes were used. This, though important with small houses, is much less so with large ones, where a man may be profitably employed to attend to the heating at night.

A point in favor of the small pipes was the greater rapidity with which they could be heated up. After starting the fire it took nearly three hours to heat the large pipes to their usual temperature and only one and one-half hours to heat the small ones. This difference would doubtless have been somewhat less marked if, as is often recommended, the total length of the small pipes had been increased until their combined radiating surface was equivalent to that of the large pipes, for there would then have been less difference between the quantities of water to be heated in the two cases.

Other points which must be considered in the selection of either system are the cost of material, the ease with which the respective systems may be varied to suit different conditions, etc. The cost per square foot of radiating surface is not very different in the two cases. As to ease of manipulation, the wrought-iron pipes can be readjusted to suit new conditions very much more readily than the cast-iron pipes.

IS CORN SMUT INJURIOUS TO CATTLE ?

The opinion is more or less prevalent that eating corn smut is injurious to cattle. The so-called cornstalk disease of cattle has erroneously been attributed to this cause, and it is also quite widely believed that corn smut causes abortion in cows.

Several years ago the Bureau of Animal Industry of this Department reported the results of feeding large quantities of corn smut to two heifers. They consumed with a normal grain ration 3 to 5 pounds of corn smut daily for some sixteen days. The temperature of the animals was taken every morning and evening. They appeared to be perfectly well throughout the experiment, and continued in good health for several months during which they were under observation after the experiment closed.

The results of similar experiments have been recently published by the Michigan Station. The corn smut was analyzed, and found to contain considerable nutritive material. In composition it resembles the coarse fodders rather than the concentrated feeding stuffs, as shown by the following table, in which it is compared with corn and oats as examples of the first group, and cornstalks, corn fodder, and clover hay, as examples of the second group.

Comparison of corn smut with a number of feeding stuffs.

	Water.	Protein.	Fat.	Nitrogen- free extract.	Fiber.	Ash.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Corn smut.....	8.3	13.1	1.4	a 29.6	24.7	22.5
Corn.....	10.9	10.5	5.4	69.6	2.1	1.5
Oats.....	11.0	11.8	1.8	59.7	2.7	3.0
Cornstalks.....	68.4	1.9	.5	17.0	11.0	1.2
Corn fodder.....	42.2	4.5	1.6	34.7	14.3	2.7
Clover hay.....	15.3	12.3	3.3	38.1	24.8	6.2

a Including 4 per cent sugar.

The ash of the corn smut was found to be rich in phosphates of potash and magnesia, like the ash of grain. In the analyst's opinion, the high percentage of ash was due to sand accidentally present in the corn smut. The smut was examined for poisonous alkaloids, but none were found. In this respect it differs from ergot, the smut on rye, from which the alkaloid ergotin has been isolated. As is well known, ergotin possesses powerful physiological properties.

It is a matter of common observation that cattle eat corn smut readily. This is explained as very probably due to the considerable quantity of sugar which it contains. In the feeding tests reported by the Michigan Station corn smut in varying amounts was fed to three grade Short-horn cows and one grade Jersey cow in addition to a ration of corn, wheat bran, ground oats, and linseed meal. The cows were in different stages of lactation (the milking period). Two of the cows were fed as large quantities of smut as they could be induced to eat, the amount being increased from 2 ounces at the start to 11 pounds per day. It is evident that the cows received in this daily ration more smut than they could possibly get in foraging over a cornfield after the removal of the crop or in stables in winter when fed exclusively upon cornstalks as coarse fodder. At the beginning of the test the cows ate the smut very readily, and the two receiving it in moderate quantities continued

to prefer it to the grain ration up to the close of the test. On the other hand, the cows receiving large quantities did not eat it so readily, though it was never entirely rejected. The test lasted forty-nine days. The gains in weight for each cow were recorded and the temperature of the animals was also taken on alternate days. During the last half of the test the dung of the cattle fed corn smut was somewhat darker in color than normal. No signs of abortion appeared in the pregnant cows. The milk yield in the case of the cows giving milk was regular and constant, and no indication was given of any variation in this respect from normal conditions.

The conclusion was drawn from this experiment that when cows are gradually brought into the habit of consuming large quantities of smut it does not appear injurious to them. What the result would be if cows unaccustomed to it suddenly gained access to large quantities must remain for future experiment. It is probably safe to say, however, that the quantity of smut that would be likely to exist in a corn-field or on the stalks as fed under normal conditions to cows would not be dangerous to the health of the animals.

The life history of the fungus causing corn smut is given below. In view of the injury to the corn crop due to this fungus precautions should be taken to prevent its spread. The digestive processes do not injure the spores, and dung of cattle consuming corn smut, unless thoroughly composted and rotted, will spread the fungus to subsequent crops. For this reason alone it is not desirable that cattle should eat corn smut, though it possesses some nutritive value. If, however, it is accidentally eaten by cattle this need occasion no alarm, since the evil effects which have been attributed to it do not follow.

CORN SMUT.

On account of some of the possible consequences of feeding corn smut, experiments with which are noted above, it has seemed desirable to give a brief résumé of what is known of the life history of the fungus causing this disease. The well-known cancerous outgrowths, with their thin, almost veil-like, covering over the black dust-like masses, need no description for their recognition (fig. 1). Everyone at all acquainted with corn culture has some knowledge of this trouble. No part of the plant escapes, although the common impression is that the ears and tassels are the portions most attacked. Investigations made in Ohio and Kansas show that the leaves and stalks are most affected. The damage done to the corn crop varies with the season and is sometimes quite considerable. The estimated loss in Ohio in the crop of 1895 was \$125,000. The loss is not alone confined to those ears which are rejected on account of their showing the smut masses, but it has been found in Kansas that plants showing attacks of smut without any indication of affection on the ear give a smaller yield than plants not attacked.

For some time it was thought that the fungus of corn smut gained entrance into the plant in the same way as those of other cereals, where the entrance must be made within a short time after the sprouting of the seed, and having entered the plant the fungus lives in the tissues, growing as they grow, and finally emerging somewhere as a smut mass. Experiments conducted in Indiana, Germany, and elsewhere show that the corn smut is quite unlike the smuts of oats, wheat, barley, etc., in that it can secure entrance into the corn plant at any time while the tissues are actively growing, and when entrance has been secured it sets up a local infection, the smut masses always reappearing within a comparatively short distance of the point of entrance.

The spores of the smut (fig. 2, A), which in mass make up the black powder, do not, as a rule, directly infect the corn. According to one investigator they sprout very poorly in water, but grow readily in nutrient solutions, such as liquid manure, moist dung heaps, damp, well-manured soil, etc. After germinating, the spore sends up a short, greatly branched stem, bearing at the ends of the branches chains of minute bead-like bodies, to which the name conidia has been given (fig. 2, B). It is through the agency of these that most if not all the infection takes place. When some of these conidia are blown upon a corn plant and alight upon a portion that is actively growing, they soon germinate, especially if the requisite moisture from dew or other sources is present, and penetrate the cell walls of the plant. Once inside, growth is extremely rapid, and in about three weeks smut boils may be seen appearing. Spores from these new masses finding a suitable location, usually the ground, germinate, form their conidia, and are ready to infect some other portion of the plant, so that during the growing season there may be, and undoubtedly are, several distinct infections of the same plant.

The presence of manure in the soil is an important factor in the spread of corn smut. Well-manured soil undoubtedly greatly favors the rapid germination of the spores and production of conidia. Fresh dung from animals that have eaten smut in all probability is a very effective means for carrying the spores to the cornfield, since the digestive processes do not destroy all of the spores, nor is the length of time required for their destruction in rotting manure definitely known. The spores ordinarily retain their vitality for a considerable time, and on



FIG. 1.—Effect of smut on ear of corn (after Brefeld).

this account the source of the manure for the cornfield should be well looked after.

For most of the smuts of the other cereals there are methods of treating the seed prior to sowing that, to a great degree, prevent the subsequent attack of the fungus, but from what has been said above obviously there is no such means for preventing corn smut. Experiments have shown that the frequent spraying of the plants and ground with any of the better known fungicides will prevent a serious spread of the disease, but in practice this will hardly be warranted on account of the expense of such treatment. Possibly a more economical and as efficient means to be recommended is the collection and burning of all smut masses before they ripen and scatter their spores. Much could be accomplished in this way by keeping a sharp lookout for the smut

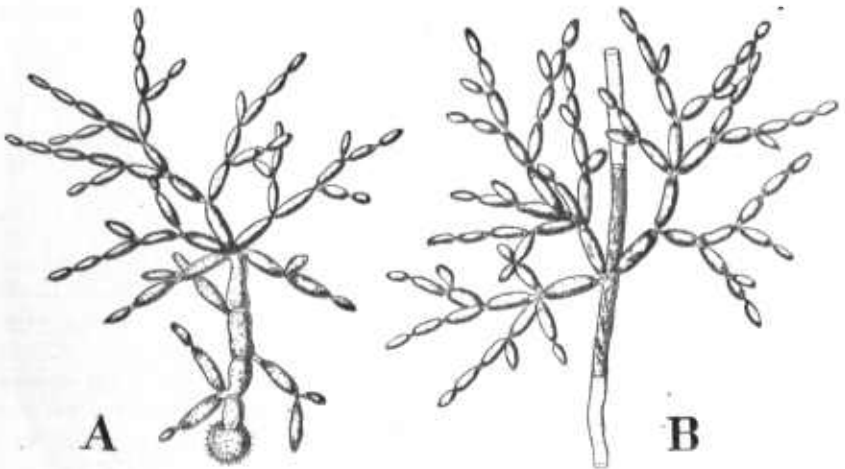


FIG. 2.—Microscopical appearance of corn smut (after Brefeld). A: A germinating spore of corn smut showing the conidia. B: The conidia from the mycelium of corn smut. (The spore and conidia are highly magnified.)

boils at every cultivation and at the harvesting of the crop. If attention be paid to the manure and the smut be collected and destroyed as recommended but little loss will be occasioned by corn smut.

MILLET DISEASE OF HORSES.

In many sections of the West and Middle West millet is a common hay crop. It is harvested and handled in the same manner as other hay. The usual practice is to harvest the crop before the heads are fully ripe, as there is a popular belief that the ripe heads are injurious to horses. Several years ago the North Dakota Station reported that a large number of horses had been affected with so-called "millet disease." This was characterized by symptoms resembling rheumatism and derangement of the urinary system. The name millet disease was adopted from the fact that nearly 100 per cent of the horses affected

had been fed upon millet. In the few cases in which the disease was said to occur when millet was not fed the symptoms of derangement of the kidneys were absent.

A number of cases of millet disease were investigated by the North Dakota Station. After feeding considerable quantities of millet the urine for a time was very abundantly secreted. Lameness and rheumatic symptoms soon occurred, and were accompanied by a suppression of urine. Later the lameness became very severe, and fever was observed also. A considerable proportion of the cases terminated fatally.

Very recently this station has published the results of further experiments on the subject of feeding millet. Two tests were made. In the first trial two geldings in good health were fed hay and grain for about two weeks. Millet was then substituted for hay for about ten days. The same ration as at the beginning was then fed for four days. All the horses were driven daily for exercise. The symptoms of lameness accompanied by suppressed urine, previously noted, were observed in these cases also.

The second test was similar to the first, and was made with two mares. One of the mares became very lame and could hardly stand, and suffered from time to time from retention of the urine. She was killed and post-mortem examination of the carcass showed a very diseased condition. The other mare did not show as marked symptoms during the test. However, when fed millet for about three months she would become so lame in the joints of the hind legs that it was almost impossible for her to walk. When feeding millet was discontinued she would recover. The lameness was again produced by millet feeding. After about two years of alternate periods of millet and hay feeding she became practically worthless.

From these experiments and observations it would appear that feeding millet alone as a coarse fodder is injurious to horses. It produces an increased action of the kidneys, and causes lameness and swelling of the joints. It causes an infusion of blood into the joints, and destroys the texture of the bone, rendering it soft and less tenacious, so that the ligaments and muscles are easily torn loose.

The experience of many farmers confirms the results of these experiments.

The bad effects due to millet were observed whether the crop was cut just before the heads were fully ripe or earlier.

Although the work of the station seems to show conclusively that feeding millet produces millet disease, the specific cause to which the dangerous properties of millet are due has not yet been discovered.

TUBERCULOSIS.

Tuberculosis in cattle and other animals is identical with the disease of man commonly known as consumption. It may readily be communicated from man to the lower animals, and also from the lower animals to man. In the latter case the infection occurs principally through the

meat and milk of diseased animals. Cattle are apparently more subject to the disease than are other farm animals. Statistics on this subject, although quite variable and in many respects unreliable, show that no country is free from the disease. While the prevalence of this disease both in the human species and in the lower animals has long been well known it is only within comparatively recent years that there has been found in the so-called tuberculin test an accurate means of detecting tuberculous animals in the early stages of the disease. This test has been studied by a large number of stations, and its value for diagnosis of the disease has been firmly established. The importance of this can hardly be overestimated in view of the widespread occurrence of the dreadful disease and the extreme necessity of reducing its ravages by destroying as far as possible all sources of infection.

The different degrees to which different grades or classes of animals are affected has recently been brought out by investigations by the experiment station in Minnesota, where, of some 13,366 animals subjected to the tuberculin test, native animals were found to be diseased to the extent of 7.8 per cent, high-grade animals to the extent of 10.8 per cent, pure breeds, 16.6 per cent; farm herds, 14.2 per cent (omitting 55 animals from two herds, 7.8 per cent), and city dairy herds, 10.4 per cent. The animals in these tests were also graded with respect to the condition of the stables in which they were kept, with the result of showing that stable conditions are very important. Under good stable conditions 10.1 per cent (omitting 55 animals in two herds, 6.8 per cent) was affected; under fair conditions of stable, 7.28 per cent, and under poor conditions of stable, 19.1 per cent. Similar results were obtained by a comparison with respect to the ventilation of stables, 9.5 per cent (omitting 55 animals in two herds, 5 per cent) being affected in well-ventilated, 6.16 per cent in fairly well ventilated, and 16.6 per cent in poorly ventilated buildings. In general these results are about what the laws of health would lead one to expect; but the existence of two badly infected herds where the conditions were most favorable to health shows that the disease may prevail even where a very considerable amount of care is taken in the way of ventilation and general sanitary condition of buildings. Such a prevalence of the disease is doubtless due to an introduction of diseased animals—it may be in efforts to improve the breed of stock—and emphasizes the fact that the breeder can scarcely be too careful in introducing animals into his herd. This is especially important in case of well-bred animals, which, as shown above, for various reasons seem to be more predisposed to disease than ordinary farm animals.

Statistics have been gathered which indicate that steers and bulls are less subject to the disease than cows, and calves less than older animals. In fact, it has come to be generally recognized that newly born animals are only rarely affected with tuberculosis.

In this connection the results of an investigation of 27 calves from

tuberculous cows in Minnesota are very interesting. Of these 27 calves one died soon after birth and was found to be tuberculous, and two others, one fed by sucking the dam and the other on sterilized milk, became tuberculous. The rest were raised on milk from tested cows and upon sterilized milk, and at the end of the experiment were, as shown by tuberculin tests, in a sound condition. This gives a little over 11 per cent of tuberculous calves from tuberculous dams, and in only one case, or a little over 3.7 per cent, is there evidence of infection before birth.

In European experiments, of 67 calves fed on the milk of untested cows nearly 40 per cent became tuberculous, while of 109 fed on milk from tested cows less than 19 per cent became infected. In a later experiment with 78 calves reared on milk from healthy cows, 15 per cent became diseased.

These experiments encourage the hope that this disease may be gradually eliminated, not only from small herds, but eventually from entire countries by adopting the well-known method in which herds are divided into groups of diseased and healthy animals which are kept separate from one another, and calves from diseased animals are reared on sterilized milk or on milk from healthy cows.

RESTORING THE CONSISTENCY OF PASTEURIZED CREAM.

Within the past few years the use of pasteurized cream for domestic purposes has spread quite extensively. The example of several of the experiment stations in putting up pasteurized cream in sealed bottles has been followed to some extent by dairymen in cities, and the practice seems likely to become quite widespread. The advantages of pasteurized cream are that it is more convenient to handle, there is less loss from spoiling, and it is free from disease germs. The cream will keep for several days without souring, so that a small jar of it can be kept on hand for use from day to day until exhausted. It has proved so convenient to housekeepers that it has come into regular use in many families which had hitherto not cared to bother with buying the small daily supply of cream needed for coffee and other purposes.

A quite serious practical objection which has been made to pasteurized cream is its lack of consistency. The cream does not appear to be as rich as normal cream because it is "thinner" and less viscous, and does not whip as readily. So strong has this objection become on the part of the consumers that it has materially retarded the further introduction of this method of supplying cream. The Wisconsin Station has been studying the problem for some time, and has recently suggested a remedy. It has found that the consistency of pasteurized cream may be completely restored by the addition of lime in solution. On account of the slight solubility of lime the use of simple limewater is impracticable, as it dilutes the cream to an undesirable degree, although even limewater materially increases the consistency of pas-

teurized cream. It is proposed to use lime dissolved in a solution of granulated sugar (suerato of lime). Such a lime solution contains more than a hundred times as much lime as limewater. Consequently it may be added to cream in sufficient quantity to produce the desired result without perceptibly changing the cream otherwise. This solution of lime in sugar is called "viscogen" on account of its viscos-producing properties, and the treated products are called "visco-cream," "visco-milk," etc.

"Viscogen" is not a commercial article, but may be easily prepared. The method described by the station for its preparation is as follows:

Two and one-half parts by weight of a good quality of cane sugar (granulated) are dissolved in five parts of water and one part of quicklime gradually slaked in three parts of water. This milk of lime should be poured through a wire strainer to remove coarse unslaked particles and then added to the sugar solution. The mixture should be agitated at frequent intervals and after two or three hours allowed to settle until the clear supernatant fluid can be siphoned off.

Where large quantities are made, we have found it convenient to mix the ingredients in a revolving barrel churn. The clear liquid (viscogen) should be kept in well-stoppered bottles, which are filled full, for the reason that it absorbs carbonic acid from the air, thus reducing its strength, and also because, where air has access to the solution, it darkens in color after a time. This latter chemical change, however, does not seem to impair its usefulness.

The quantity of lime recommended in the above formula is considerably more than will be dissolved by the sugar solution. This excess is added because of the impurities contained in our Wisconsin lime, which is of dolomitic origin, and hence contains nearly as much magnesia as lime. As these impurities are practically insoluble in the sugar solution, they have no effect in the prepared viscogen.

After siphoning off the clear fluid, the residue still contains some of the sugar solution that remains turbid for a long time. This sugar can be recovered by adding considerable water to the residue and allowing it to settle again, when the clear liquid can be poured off and used in the place of an equal quantity of water in the preparation of the next lot.

The exact amount of viscogen required depends, of course, upon the amount of acid in the cream, but is usually about 1 part of viscogen to 150 parts of cream. A safe practical means of adding the right amount is to test the amount of viscogen required to neutralize a small measured quantity of cream, and then to calculate the quantity of viscogen required for the whole amount of cream. The neutral point of the cream is shown by a little phenolphthalein solution; a drop of it mixed with a drop of the cream should give a pink color which quickly disappears; if the pink color is permanent, too much viscogen has been added.

In adding the viscogen to the cream, it should be poured into the cream slowly, stirring the latter constantly, so as to get a homogenous mixture. The pasteurized cream should be cooled to a point below 60° F. before adding the viscogen.

Regarding the use of viscogen from the point of health, it is stated that the amount of lime added, when the above rules are followed, will not exceed 0.6 of an ounce of lime to 100 pounds of cream, or less than

4 parts in 10,000. It is believed that any physiological effect from this small amount of lime would be beneficial rather than injurious. Since the laws of most States prohibit the addition of any foreign substance to milk, which would make the addition of viscogen an offense, it is proposed to sell the product under the name of "viseo-cream," "visco-milk," etc. This places it in a category similar to the various proprietary lactated foods.

In its practical application viscogen may be used for the following purposes:

(1) To restore the consistency of pasteurized cream, for which use it stands pre-eminent.

(2) To increase the body of separator cream, and so overcome the objection urged against this in comparison with gravity cream.

(3) To increase the viscosity of cream designed for whipping, for which it is highly recommended, inasmuch as the kind of consistency imparted enables one to whip cream at temperatures that would otherwise be impossible.

(4) To give greater body to condensed milk where the method of preparation does not interfere with its use.

KITCHEN AND TABLE WASTES.

Good management, both on the farm and in the household, demands that all sources of waste be guarded against and that all by-products be utilized to the best advantage. That the kitchen and table wastes are more important sources of loss than are generally realized is brought out quite strikingly by investigations made by the New Jersey Station.

This station collected and analyzed the kitchen and table refuse and waste in a family consisting of one man, one woman, four boys, and two girls during three weeks. During this period there were thus collected 95.96 pounds of material, of which about 70 pounds was vegetable matter. The composition of this material and the amounts which would be collected in one year at the above rates are shown in the following table:

Amount and composition of kitchen and table wastes.

	Total amount per year.	Water.	Fat.	Ash.	Organic matter.	Nitro- gen.	Phos- phoric acid.	Potash.
	<i>Pounds.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Vegetable	1,208.31	84.46	0.22	1.83	13.71	0.30	0.12	0.54
Animal (mostly)	455.00	58.70	13.08	9.78	31.52	1.04	2.74	.30
Whole product	1,663.31	77.42	3.90	4.60	18.58	.07	.84	.47

[It is calculated that there could] be gathered annually from 20,000 people about 2,080 tons of garbage, with an analysis and value equal to good barnyard manure. By treating with suitable solvents and drying the residue there could be secured 388½ tons of fertilizer, worth \$14.69 per ton, and over 81 tons of grease, which sells for an average of \$70 per ton wherever this system is in operation. By cremation there would result 83½ tons of ashes, worth \$28.53 per ton. * * *

The total population of the cities and towns of New Jersey is approximately 918,722 and the garbage of this number of people would amount to 95,516 tons per year, from

which could be manufactured 17,848 tons of tankage, worth \$262,180, and 3,726 tons of grease, worth \$260,800, a total of \$522,980.

Should all this garbage be thus manipulated, there would be an increase in the plant-food supply to the extent of 45 per cent of the tonnage of complete fertilizers used in this State during 1894, which could not help but diminish the cost of fertilizers to the agriculturist.

SUGGESTIONS REGARDING THE SYSTEMATIC USE OF FERTILIZERS.

The fertilizer best adapted to a given crop on a particular soil can only be determined with exactness by experiment in each case. Still, the extensive experiments with fertilizers which have been carried on by the experiment stations and the practical experience of farmers on all kinds of soils and with all classes of crops have brought out certain general facts and made it possible to lay down certain very general rules regarding the application of fertilizers which may result in greater economy in their use than is possible under the haphazard methods which are so often followed. It should be understood, however, that it is impossible to draw hard and fast rules applicable under all circumstances, and that, while the farmer may profitably follow, in a general way, the directions given, he should not be unalterably bound by them, but should ever be alive to the need of studying the special requirements of his soils with a view to securing still greater economy in the use of fertilizers. Having decided that the manurial resources of the farm need supplementing, and that the use of commercial fertilizers is advisable, the constant effort should be to determine the system of application which gives the greatest return for the outlay incurred.

A report of the New Jersey Station, in discussing this subject, says:

The direct object in the use of manure is to derive a profit; this profit may be obtained either directly in the form of immediate increased production, or indirectly in the form of increased fertility in or greater general productiveness of soil, from which more profitable crops may be taken later. With few exceptions, however, the farmer desires to secure sufficient immediate increase of crop to pay for the materials applied.

In the first place, the kind of farming engaged in should exert an influence in deciding upon the kind and amount of material to use. For example, the farmer growing wheat or corn can not afford to use as much nor as expensive fertilizing materials as the farmer growing potatoes or fruit, for the former not only are products of a relatively low market value, but also contain relatively large amounts of the fertilizing constituents. On the other hand, potatoes and fruit not only are products of a relatively high value, but also contain relatively small amounts of the fertilizing constituents. For instance, in ordinary seasons the selling prices of a bushel of corn and a bushel of potatoes are about the same, and yet a bushel of corn contains fertilizing constituents that would cost in the market five times as much as those contained in a bushel of potatoes.

In other words, the kind of farming, or the relation of the market value of crop to the amount of fertilizing constituents required to obtain it, must guide in the purchase and use of manures.

The New Jersey Station has summarized the results of numerous experiments in different parts of that State on different crops and soils

which have in large part been confirmed by practical trial, and recommends the systematic methods of manuring described below as substitutes for the methods now in use. The adoption of these suggestions may not in all cases result in the growing of profitable crops, because proper manuring is only one of many influencing factors in their growth, but it is believed that in any case it will materially reduce the cost of production.

The rotations practiced in New Jersey, and which are taken into consideration in the outline of the methods offered, are as follows:

Rotations practiced in New Jersey.

Rotation.	First year.	Second year.	Third year.	Fourth year.	Fifth year.	Sixth year.
I.....	Corn...	Oats	Wheat or rye....	Clover....	Timothy..	Timothy..
II.....	Corn...	Potatoes	Wheat or rye....	Clover....	Timothy..	Timothy..
III.....	Corn...	Wheat or rye....	Clover	Timothy..	Timothy..	
IV.....	Corn...	Potatoes	Clover.....			
V.....	Corn...	Sweet potatoes ..	Potatoes	Melons ...	Clover.	
VI.....	Corn...	Sweet potatoes ..	Early tomatoes ..	Clover.		

In Rotation I the system suggested is: First, that the barnyard manure be spread on the sod during the fall, winter, or early spring, and after the land is plowed and well prepared drill or sow broadcast 200 pounds per acre either of a mixture made up of 100 pounds of ground bone and 100 pounds of muriate of potash or of a manufactured fertilizer showing 2 per cent of nitrogen, 10 of phosphoric acid, and 25 per cent of potash. When it is the custom to use a compost in the hill at time of planting, which is usually desirable, it should be continued. Second, for the oat crop, which follows in order, apply in drill or broadcast 150 pounds per acre either of a mixture made up of 25 pounds of nitrate of soda and 125 pounds of acid phosphate or of a manufactured mixture showing 3 per cent nitrogen and 10 of available phosphoric acid. Third, after plowing the land for wheat apply the yard manure that may be left over from spring or produced during the summer, covering with this as large an area as possible; that is, spread thinly rather than too thick, and at time of seeding apply 250 pounds per acre of dissolved animal bone or the same amount of a purchased fertilizer showing 3 per cent of nitrogen and 12 per cent of available phosphoric acid. This composition may be obtained from a mixture of 50 pounds of nitrate of soda, 800 pounds of fine ground tankage, and 1,150 of acid phosphate. Fourth, the clover and timothy the fourth year of the rotation need not be fertilized. Fifth, on the timothy, apply as a top dressing in spring from 100 to 150 pounds of nitrate of soda per acre. Sixth, if this crop is continued the sixth year, or even longer, apply from 300 to 500 pounds either of a mixture made up of 200 pounds of nitrate of soda, 200 pounds of acid phosphate, and 100 pounds of muriate of potash, or of a manufactured brand showing 6 per cent of nitrate nitrogen, 5 per cent of available phosphoric acid, and 10 per cent of potash. By this method only the kinds and forms of the fertilizing constituents, shown by the experiments to be the most directly useful have been applied, and in amounts sufficient to provide for largely increased crops, though only a comparatively small increase will be required in order to pay for the materials applied.

At a purchase price that, under present conditions will enable manufacturers and dealers to derive a good profit,¹ the cost per acre for corn need not exceed \$3.50; for oats, \$1.50; for wheat, \$3; and for timothy the first year, \$2.50, and for the second year, \$4.50; a total of \$15 for the six years, or an average of but \$2.50 per acre per

¹ Based on market prices of fertilizing materials prevailing in New Jersey in 1895.

year. Besides, if the increase is only sufficient to pay for the fertilizer used the land is much richer, particularly in the mineral elements, than at the beginning of the rotation. Assuming that the increased crops in the rotations have been sufficient only to pay the cost of the fertilizer used, the amounts of the constituents unused are 16 pounds of nitrogen, 50 of phosphoric acid, and 45 of potash; of these the mineral elements, which are equivalent to 400 pounds of acid phosphate and 90 of muriate of potash, are still in the soil for the use of subsequent crops. By this system whatever increase is secured has been derived at a minimum expense for manures, while at the same time the capital stock of the farmer, viz, essential constituents of fertility, has been largely increased. [In other words, it is suggested that in the purchase, application, and use of fertilizers rational and systematic methods be substituted for irrational and unsystematic methods.]

Rotation II differs from No. I in that a crop of relatively high value has been substituted for the oats. In this rotation the application for corn may be the same as in No. I. For the potatoes, because maximum crops can only be assured by the presence in the soil of an abundance of available plant food of all kinds, the application of either 650 pounds per acre of a mixture showing 3.5 per cent of nitrogen, 7 per cent of phosphoric acid, and 15 of potash, or 50 pounds of nitrate of soda, 100 of dried blood, 100 of bone, 200 of acid phosphate, and 200 of muriate of potash is recommended. Because of the low content of fertilizing constituents in the potatoes an increased crop, only sufficient to pay the cost of the fertilizer, would leave a much greater residue for subsequent crops than in No. I; hence, unless rapid soil improvement is an important consideration, the application for the wheat may be reduced to one-half, while the timothy may be fertilized as in No. I. The cost of the fertilizers for this rotation would be \$20.50, or at the rate of \$3.42 per year, while the residue, calculated on the same basis as in No. I would consist of 25 pounds of nitrogen, 60 of phosphoric acid, and 140 of potash, or equivalent to that contained in 150 pounds of nitrate of soda, 500 of acid phosphate, and 280 of muriate of potash.

Rotation III differs from No. I in that the oat crop is omitted and the wheat or rye is seeded after the corn. The farm manure is applied to the same crops and in the same manner as in No. I. The fertilizing may also be the same; hence the average yearly cost of fertilizers would be slightly increased over No. I and the gain in added fertility more rapid.

Rotation IV is a short rotation of corn, potatoes, and clover; the frequency of the improving crop, clover, and because only two crops out of the three need direct fertilization, renders this rotation a very useful one. In this it is preferable that the farm manures be all used upon the corn, because of the tendency of the manure to favor scabiness in the potatoes.

This fertilization for the corn and potatoes may be the same as in the other cases, though because of the very rapid accumulation of unused residue, particularly if the clover grown is fed upon the farm and the manure carefully saved and used, the amounts applied may be considerably reduced after the second rotation course is completed. The cost of the fertilization would be \$14 for the rotation course, while the accumulation of mineral constituents would be equivalent to 400 pounds acid phosphate and 280 of muriate of potash. In this rotation, too, the accumulation of nitrogen would be much more rapid than in the others, due to the greater frequency of the clover crop, a point recognized and appreciated by all practical farmers.

Rotation V is practiced only in those sections where the soil is not rich in natural fertility; hence the crops are more dependent upon added supplies of plant food than in the rotation already studied. It is a long, though because of the character of the crops it is not an exhaustive rotation. The farm manures may be divided between the corn and melon crops. For the former the coarser manures should be broadcasted during the winter, and for the melons the manure should be well rotted and applied in the hill.

The fertilizers for the corn may consist of 200 pounds per acre of a mixture of 100 pounds of acid phosphate and 100 of muriate of potash; the yard manure and the

clover soil, in addition to the compost in the hill, will usually furnish sufficient nitrogen. For the sweet potatoes, apply when making up the hills a mixture containing 2 per cent of nitrogen, 8 of phosphoric acid, and 16 of potash, which may be derived from 50 pounds of nitrate of soda, 100 of ground bone, 250 of acid phosphato, and 200 of muriate of potash. For the white [Irish] potatoes apply the same amount and kind of fertilizer as is recommended in the previous rotations, and for the melons, in addition to the yard manure, 600 pounds of a fertilizer containing 3.5 per cent of nitrogen, 8 per cent of phosphoric acid, and 8 per cent of potash, which may be derived from 300 pounds of cotton-seed meal, 100 of ground bone, 200 of acid phosphate, and 100 of muriate of potash. This system of practice may be regarded as intensive, since with one exception the crops are provided with such an abundance of plant food as to insure maximum production, under ordinary conditions of season, without depending upon soil supplies. The cost of fertilizing is, however, not expensive; \$33 will provide for the five-year rotation, or an average of only \$6.50 per year, accompanied with a very rapid accumulation of unused residue. In order to retain as far as possible the accumulated nitrogen, the frequent use of catch crops is strongly recommended.

In Rotation VI the farm manures may be divided between the corn and tomatoes, the coarser for the corn and the well-rotted for the tomatoes, the fertilizers for corn and potatoes to be the same as for No. V. For the tomatoes apply, in addition to the well-rotted manure, 160 pounds per acre of nitrate of soda, one-half to be applied at time of setting the plants and one-half three or four weeks later. If late tomatoes are raised, apply, in addition to the nitrate of soda at the first application, 300 pounds per acre of a mixture made up of 100 pounds of ground bone, 100 of acid phosphate, and 100 of muriate of potash. The fertilization in this rotation is less expensive than in No. V and the accumulation of residue less rapid.

EXPLANATION OF TERMS.

TERMS USED IN DISCUSSING FERTILIZERS.

Complete fertilizer is one which contains the three essential fertilizing constituents, i. e., nitrogen, phosphoric acid, and potash.

Nitrogen exists in fertilizers in three distinct forms, viz, as organic matter, as ammonia, and as nitrates. It is the most expensive fertilizing ingredient.

Nitrates furnish the most readily available forms of nitrogen. The most common are nitrate of soda and nitrate of potash (saltpeter).

Phosphoric acid, one of the essential fertilizing ingredients, is derived from materials called phosphates. It does not exist alone, but in combination, most commonly as phosphate of lime in the form of bones, rock phosphate, and phosphatic slag. Phosphoric acid occurs in fertilizers in three forms—soluble, reverted, and insoluble phosphoric acid.

Soluble phosphoric acid is that form which is soluble in water and readily taken up by plants.

Reverted phosphoric acid is that form which is insoluble in water but still readily used by plants.

Available phosphoric acid is the soluble and reverted taken together.

Superphosphate.—In natural or untreated phosphates the phosphoric acid is insoluble in water and not readily available to plants. Superphosphate is prepared from these by grinding and treating with sulphuric acid, which makes the phosphoric acid more available to plants. Superphosphates are sometimes called acid phosphates.

Potash, as a constituent of fertilizers, exists in a number of forms, but chiefly as chlorid or muriate and as sulphate. All forms are freely soluble in water and are believed to be nearly, if not quite, equally available, but it has been found that the chlorids may injuriously affect the quality of tobacco, potatoes, and certain other crops. The chief sources of potash are the potash salts from Stassfurt, Germany—kainit, sylviit, muriate of potash, sulphate of potash, and sulphate of potash and magnesia. Wood ashes and cotton-hull ashes are also sources of potash.

TERMS USED IN DISCUSSING FOODS AND FEEDING STUFFS.

Water is contained in all feeding stuffs. The amount varies from 8 to 15 pounds per 100 pounds of such dry material as hay, straw, or grain, to 80 pounds in silage and 90 pounds in some roots.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorine, and carbonic, sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is stored up in the animal's body; the rest is voided in the manure.

Organic matter is the dry matter less the ash.

Protein (nitrogenous matter) is the name of a group of substances containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, casein of milk, albumen of eggs, etc., and is one of the most important constituents of feeding stuffs.

Fiber, sometimes called crude cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar, gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains.

Fat, or the materials dissolved from a feeding stuff by ether, is a substance of mixed character, and may include, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

MISCELLANEOUS TERMS.

Microorganism, or **microscopic organism**, is a plant or animal too small to be seen without the aid of a compound microscope.

Sterilized milk or cream, properly speaking, is that in which all the germs have been destroyed (usually by repeated heating to 212° F.—boiling point), but in dairy practice the term is applied to milk or cream which has been heated once to a temperature of about 212° F.

Pasteurized milk or cream is that which has been heated to a temperature (about 155° F.) which does not kill all the bacteria, but only those which are in a vegetating condition and ready to begin their activity at once.

Fungus is a low form of plant life destitute of green coloring matter; mold is an example.

Fungicide is a substance used to destroy fungi or prevent their growth.

Spore is a minute body, borne by a fungus, which is capable of reproducing the fungus directly. It corresponds in function with the seed of higher plants.

Conidium (plural **Conidia**) is one form of spore or reproductive body of fungi.

Tuberculin is a liquid in which the germs of tuberculosis have been grown but from which all live germs of the disease have been carefully removed. It is administered by hypodermic injection as a test for tuberculosis in animals, a rise of temperature after injection indicating the presence of the disease.

Viscosity is the quality of being viscous, or flowing slowly, as molasses.

Alkaloids are a class of bitter, nitrogenous constituents of plants which have active medicinal or poisonous properties. Quinin, morphin, strychnin, etc., are alkaloids.

Flow pipes and returns.—In the heating systems of greenhouses it is a common practice to have one or two main pipes, known as flow pipes, to supply the steam or hot water to the house. These pipes frequently run the full length of the house and then unite with smaller pipes known as return pipes, or "returns," which carry the hot water or steam through the house and back to the boiler.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C. Only the following are available for distribution:

- No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
- No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
- No. 18. Forage Plants for the South. Pp. 30.
- No. 10. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
- No. 21. Barnyard Manure. Pp. 32.
- No. 22. Feeding Farm Animals. Pp. 32.
- No. 23. Foods: Nutritive Value and Cost. Pp. 32.
- No. 24. Hog Cholera and Swine Plague. Pp. 16.
- No. 25. Peanuts: Culture and Uses. Pp. 24.
- No. 20. Sweet Potatoes: Culture and Uses. Pp. 30.
- No. 27. Flax for Seed and Fiber. Pp. 10.
- No. 28. Weeds; and How to Kill Them. Pp. 30.
- No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23.
- No. 30. Grape Diseases on the Pacific Coast. Pp. 16.
- No. 31. Alfalfa, or Lucern. Pp. 23.
- No. 32. Silos and Silage. Pp. 31.
- No. 33. Peach Growing for Market. Pp. 24.
- No. 34. Meats: Composition and Cooking. Pp. 29.
- No. 35. Potato Culture. Pp. 23.
- No. 36. Cotton Seed and Its Products. Pp. 10.
- No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
- No. 38. Spraying for Fruit Diseases. Pp. 12.
- No. 39. Onion Culture. Pp. 31.
- No. 40. Farm Drainage. Pp. 24.
- No. 41. Fowls: Care and Feeding. Pp. 24.
- No. 42. Facts About Milk. Pp. 20.
- No. 43. Sewage Disposal on the Farm. Pp. 22.
- No. 44. Commercial Fertilizers. Pp. 24.
- No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
- No. 46. Irrigation in Humid Climates. Pp. 27.
- No. 47. Insects Affecting the Cotton Plant. Pp. 32.
- No. 48. The Manuring of Cotton. Pp. 16.
- No. 49. Sheep Feeding. Pp. 24.
- No. 50. Sorghum as a Forage Crop. Pp. 24.
- No. 51. Standard Varieties of Chickens. Pp. 48.
- No. 52. The Sugar Beet. Pp. 48.
- No. 53. How to Grow Mushrooms. Pp. 20.
- No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
- No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
- No. 56. Experiment Station Work—I. Pp. 30.
- No. 57. Butter Making on the Farm. Pp. 15.
- No. 58. The Soy Bean as a Forage Crop. Pp. 24.
- No. 59. Bee Keeping. Pp. 32.
- No. 60. Methods of Curing Tobacco. Pp. 16.
- No. 61. Asparagus Culture. Pp. 40.
- No. 62. Marketing Farm Produce. Pp. 28.
- No. 63. Care of Milk on the Farm. Pp. 40.
- No. 64. Ducks and Geese. Pp. 48.
- No. 65. Experiment Station Work—II. Pp. 32.
- No. 66. Meadows and Pastures. Pp. 24.
- No. 67. Forestry for Farmers. Pp. 48.
- No. 68. The Black Rot of the Cabbage. Pp. 22.
- No. 69. Experiment Station Work—III. Pp. 32.
- No. 70. The Principal Insect Enemies of the Grape. Pp. 24.
- No. 71. Some Essentials of Beef Production. Pp. 24.
- No. 72. Cattle Ranges of the Southwest. Pp. 32.
- No. 73. Experiment Station Work—IV. Pp. 32.
- No. 74. Milk as Food. Pp. 30.
- No. 75. The Grain Smuts. Pp. 20.
- No. 76. Tomato Growing. Pp. 30.
- No. 77. The Liming of Soils. Pp. 10.
- No. 78. Experiment Station Work—V. Pp. 32.
- No. 79. Experiment Station Work—VI. Pp. 28.
- No. 80. The Peach Twig-borer—an Important Enemy of Stone Fruits. Pp. 10.
- No. 81. Corn Culture in the South. Pp. 24.
- No. 82. The Culture of Tobacco. Pp. 23.
- No. 83. Tobacco Soils. Pp. 23.
- No. 84. Experiment Station Work—VII. Pp. 32.
- No. 85. Fish as Food. Pp. 30.
- No. 86. Thirty Poisonous Plants. Pp. 32.
- No. 87. Experiment Station Work—VIII. (In press.)
- No. 88. Alkali Lands. Pp. 23.
- No. 89. Cowpeas. (In press.)